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Ministry of the Environment

Ontario

ENVIRONMENTAL BASELINE REPORT OF THE NIAGARA RIVER

...tario Review Board

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Date Due

ENVIRONMENTAL BASELINE STUDY OF THE NIAGARA RIVER
"EXECUTIVE SUMMARY"

In response to growing concern about toxic substances in the Great Lakes, Canada and Ontario have intensified their coordinated monitoring and surveillance programs. The Niagara River is receiving particular attention because of the potential adverse impact of numerous abandoned waste disposal sites and proposed new discharges to the River. This report by the Canada/Ontario Review Board summarizes Canadian data on water, suspended sediment, bottom sediment and biota collected in the Niagara River between 1975 and 1979. It is intended that this information will provide a baseline for determining trends in environmental quality, assessing the effectiveness of pollution abatement programs and predicting the potential effects of future developments.

In general, over the period 1975-1979, yearly average water quality conditions in the Niagara River met the objectives of the 1978 Canada/U.S. Great Lakes Water Quality Agreement and those of the Ontario Ministry of the Environment. Concentrations of some metals and organic compounds occasionally exceeded these objectives but in less than 10% of the samples analyzed. Concentrations of iron, manganese, and zinc were generally observed to be higher on the U.S. side of the Niagara River.

Analyses of samples of raw water taken from the Niagara-on-the-Lake and Niagara Falls (Ontario) water treatment plants and from the Niagara River adjacent to the town of Fort Erie met federal and provincial criteria for acceptable drinking water. Results from a 1977 survey conducted by MOE which included 40 surface water supplies in the province indicated that the Niagara-on-the-Lake supply had concentrations of substances close to the median value from all plants.

The Niagara River Basin is a continuous source of organic compounds and metals associated with suspended sediments to Lake Ontario. For example, annual loading of suspended sediment-associated PCBs to the Lake is approximately 530 kg/yr. The major portion of the loading of PCBs and some pesticides enters the River adjacent to or downstream from Grand Island, New York. The Love Canal and Buffalo River areas in New York are also sources for numerous organics. Results of analyses of suspended sediment samples indicated instances of high concentrations of PCBs and Hexachlorobenzenes (HCBs) 3 to 5 times the mean values detected. These instances of high concentrations could not be correlated with storm events, and it is suspected that they resulted from intermittent direct effluent discharges of these substances to the River. Investigations are continuing.

All bottom sediment samples from the lower Niagara River and 83% of the samples from the upper Niagara River had concentrations of PCBs exceeding 50 parts per billion which is Environment Ontario's dredge spoil criterion. Also, a large percentage of sediment samples from the slower-moving section of the lower Niagara River exceeded the dredge spoil criteria for arsenic, chromium, and mercury indicating that the river section downstream from Queenston is an accumulation area for contaminated sediments. Further comparison of concentrations at various river locations is awaiting the completion of sediment particle size and organic carbon analyses.

Since monitoring of fish (spottail shiner) began in 1975 at Niagara-on-the-Lake, PCB residues have declined by 78%, mercury residues by 33% and total DDT residues by 89%. Comparison of contaminant residue data in spottail shiners from two Niagara River sites with those from the control station at Thunder Bay (Lake Erie) indicates the presence of PCB, DDT, mirex, HCB and mercury sources in the River.

Various size ranges of coho salmon, smelt and lake trout caught in 1979 in the lower Niagara were fit for only "occasional consumption" due to excessive levels of PCBs and mirex.

The following conclusions were drawn:

(1) Yearly average water quality conditions in the Niagara River over the period 1975-1979 met the 1978 Canada/U.S. Great Lakes Water Quality Agreement water quality objectives. Concentrations exceeding the objectives for some metals and organic compounds occurred in less than 10% of the samples analyzed.

(2) All water samples taken along the Ontario shoreline of the river met the Canadian criteria for drinking water. (Health implications of a number of organics for which no objectives now exist are being investigated, e.g. halogenated aliphatics other than trihalomethanes, and aromatic hydrocarbons).

(3) Concentrations of PCBs, total DDT and mercury have declined significantly since 1975 in spottail shiners (an indicator forage fish species) caught at Niagara-on-the-Lake. Specific objectives for the protection of fish and other biota have not been established for a number of organic compounds present in the Niagara River ecosystem. Further investigation is proceeding under the Canada/U.S. Agreement.

(4) The Niagara River is a continuing source of numerous metals and organic compounds, including mercury, PCBs, mirex and DDT, to Lake Ontario because there are continuing inputs of these substances to the Niagara River itself. The range in observed concentrations of metals and organic compounds at the mouth of the river indicates that these inputs to the River are both variable and intermittent.

(5) While surveillance efforts of river water quality have been increased, industrial and municipal effluent monitoring with respect to synthetic organics and other potentially toxic substances should be strengthened.

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I. Background

In recent years, concern has developed over the recurring detection of persistent toxic substances in the Great Lakes Basin and their varied and uncertain effects on the ecosystem. Accordingly, the 1978 Agreement on Great Lakes Water Quality between Canada and the United States, which contains many new water quality objectives for the control of toxic substances, also provides for co-ordinated programs and measures for their control.

In this regard, problems associated with major waste disposal sites, both old and new, and proposals for additional waste discharges to the Niagara River from New York State have become issues of increasing public concern. This concern developed during a period when significant progress in the control of municipal and industrial pollution had been made, following the 1972 Agreement on Great Lakes Water Quality. Nevertheless, water quality problems due to bacterial and phenol contaminants were reported to persist by the IJC (IJC - Great Lakes Water Quality, 1978 Annual Report) because corrective programs undertaken under the 1972 Agreement had yet to be completed. While there may have been some improvement in these conditions, many of these problems will remain until a number of major municipal and industrial projects initiated since 1972 are completed.

To assess progress and increase understanding of the complex water quality problems associated with persistent toxic substances, Canada and Ontario have conducted intensive surveillance and monitoring of the Niagara River in recent years. Measurements of a wide range of parameters in water, sediments, supended sediments, fish, herring gulls and other biota, have been made jointly by the federal and provincial governments in consultation with U. S. federal and state authorities.

This report, undertaken by the Review Board of the Canada-Ontario Agreement on Great Lakes Water Quality, focuses on the water quality problems resulting from inadequate control of toxic substances, as evidenced by their presence in the Niagara River and Lake Ontario.

A. CONDITION OF THE NIAGARA RIVER

(1) Data Sources

From 1966 to 1973, Environment Ontario (MOE) conducted annual intensive surveys of water quality in the upper and lower reaches of the Niagara River. Thereafter, under the provisions of the Great Lakes International Surveillance Plan, monitoring of the river was carried out by the New York State Department of Environmental Conservation and Environment Canada (DOE).

Since 1975, the Water Quality Branch (Inland Waters Directorate (IWD), Ontario Region, Environment Canada) has undertaken the following programs (Figure 1):

- surveys of heavy metals, PCBs and pesticides at fixed ranges in the upper and lower Niagara River in 1975 and again in the upper Niagara River in 1979.
- weekly sampling of water at a fixed station in the Lower Niagara River adjacent to Niagara-on-the-Lake with analysis for aluminum, cadmium, chromium, copper, iron, lead, manganese, nickel and zinc (cyanide and mercury added in 1979).
- suspended sediment sampling from the river at Niagara-onthe-Lake in 1978 and from March to December, 1979; additional samples were collected from the Upper Niagara River in July 1979. Samples were analyzed for polychlorinated biphenyls (PCBs), pesticides, polynuclear aromatic hydrocarbons (PAHs) and other organics.

Reflecting the 1978 Agreement on toxic substances, the Water Resources Branch of Environment Ontario conducted a trace contaminants survey of the Niagara River in 1979 (Figure 2). Water and sediment samples were taken at 25 stations, and, at eight of these stations, suspended sediments and biota (macrophytes,

macroinvertebrates, net plankton) were also collected. Samples were analyzed for PCBs, pesticides, arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc. Results for herbicides, other trace organics (GC/MS scan) and sediment particle size are pending.

Sources of additional information included the Canada Wildlife Service for data on freshwater clams, Environment Ontario for data on spottail shiner fish and water treatment plant raw water quality and the Fish Contaminants Monitoring Program of the Ontario Ministries of Natural Resources, Environment and Labour for data on sport fish.

(2) Water

Water quality discussed in this section is compared to the water quality objectives contained in the 1978 Canada/United States "Great Lakes Water Quality Agreement" and the Environment Ontario publication "Water Management" (1978).

While some of the objectives for the protection of aquatic life were occasionally exceeded between 1975 and 1979, the "average" yearly water quality conditions met the objectives. Drinking water quality is discussed in Section 6. In 1975, less than 10% of the samples taken during surveys in the lower Niagara River exceeded the objectives for cadmium, copper, iron, zinc, mercury, cyanide, phenols and lindane. Concentrations of total DDT, PCBs, aldrin/dieldrin, endosulfan (thiodan), lindane (γ-BHC)/α-BHC/β-BHC and cadmium also exceeded the objectives at certain stations on at least one occasion during 1979.

Between 1975 and 1979, weekly sampling at a fixed station adjacent to Niagara-on-the-Lake indicated that, apart from an increasing trend in total iron, no upward trends have occurred in the concentrations of metals. Mean annual concentrations of copper exceeded the objectives in 1976, 1977 and in 1979. In 1979,

concentrations of copper and iron exceeded the objectives frequently. The high mean annual iron concentration in 1979 results from the extraordinarily high concentrations measured in early January. This may be related to climatic events.

In the upper Niagara River, the objectives were exceeded occasionally during 1975 for mercury, cyanide and phenols, and for cadmium, copper and iron in both 1975 and 1979. The objectives for zinc, Dieldrin, PCBs, total DDT, heptachlor epoxide and endrin were exceeded occasionally in 1979. Concentrations were generally higher on the U.S. side of the river for iron, manganese and zinc.

Table A summarizes available 1979 data for those Niagara River locations where Environment Ontario stations were approximately coincident with Environment Canada ranges (for the lower Niagara River, the DOE fixed sampling station on range 1.3 was used).

Environment Canada data represent mean annual values while Environment Ontario results are from a single survey. Table A indicates some points worthy of note. First, Environment Ontario and Environment Canada samples are not analyzed for the same parameters. Second, the higher Environment Ontario detection limits for some metals has resulted in the generation of only qualitative data for cadmium, chromium, copper, lead, nickel and zinc, thus making comparisons difficult. In some cases, these routine detection limits exceed the Agreement/MOE objectives (eg: cadmium, copper, lead, total DDT + metabolites, mirex, PCBs). The Environment Ontario objective for PCBs is currently below the routine detection limit of both agencies.

(3) Suspended Sediments

Results of analyses of suspended sediments collected in the river at Niagara-on-the-Lake indicate that the Niagara River is a carrier of metals and organics including PCBs, DDT and mirex to Lake Ontario.

Based on the mean 1979 concentrations, the suspended sediment-associated PCBs, DDT and mirex loads to Lake Ontario are 533, 36.9 and 10.8 kg/yr, respectively (N.D. Warry, 1980 - "Organic Contaminants in the Suspended Sediments of the Niagara River" IWD draft report). The analyses have also indicated the presence of numerous other substances. Work is continuing on specific identification. Table B summarizes Environment Ontario and Environment Canada data for suspended sediments. Concentrations of PCBs, chromium, copper, lead, nickel and zinc were somewhat higher in the upper Niagara River whereas concentrations of α-BHC, lindane, α- and γ-chlordane, endrin, heptachlor epoxide, HCB, mirex and thiodan I and thiodan II were higher in the lower Niagara River. Results from the "control" station at Thunder Bay, Lake Erie were included for comparison. Although most pesticides were not detected at this location, there were surprisingly high concentrations of PCBs, total DDT, mirex, copper, and nickel. Further work is planned to verify the data collected at this station.

The higher variability of Environment Ontario values (as indicated by standard deviation values), particularly for the upper Niagara River (see Table B) may be due to the fact that sampling stations were situated to monitor possible sources and not general river levels as were the Environment Canada ranges.

There is considerable evidence that there are inputs of contaminants to the Niagara River. Environment Canada data for PCBs and pesticides concentrations in suspended sediments collected upstream of Grand Island and Fort Erie were always equal to or less than one half the mean concentrations reported at Niagara-on-the-Lake. This suggests that a good portion of the contaminants loading comes from discharges adjacent to or downstream of Grand Island. High levels of such contaminants as PCBs were found during the Environment Canada survey at the Love Canal and Buffalo River sites.

Concentrations of PCBs, DDT, mirex, chlordane, methoxychlor and endosulfan in suspended sediments at Niagara-on-the-Lake were quite variable with time during 1979, with concentration changes up to a

factor of three times not being unusual within a month (N. D. Warry, 1980 - "Organic Contaminants in the Suspended Sediments of the Niagara River" IWD draft report).

Figure 3 illustrates the variability in the concentration of mirex during 1979. Two distinct concentration maxima were evident: one on August 28, and the other on October 2. HCB and PCBs also reached unusually high (>3 times the mean value) concentrations in suspended sediments on these days, and p,p-DDE and α-endosulfan (thiodan I) levels were higher than usual. However, these maxima could not be directly correlated with major storm events which could have caused overflows from land disposal sites. The highest concentration of methoxychlor was detected on September 25, when lindane, p,p-DDE and PCBs levels were also high. High methoxychlor concentrations were recorded on August 21 and October 2. High (5 times the mean value) concentrations of α-BHC were also observed on August 21.

(4) Sediments

At present, Environment Ontario dredged spoil disposal criteria provide the only convenient yardstick against which sediment quality can be measured, (it is unlikely that open lake disposal of sediments from the Niagara River sampling sites would be practised). The percentage of samples which exceeded these criteria in the upper and lower reaches of the Niagara River are listed in Table C. All the stations sampled in the lower Niagara, and 83% of those sampled in the upper Niagara River, had PCB concentrations exceeding the criterion (50 ppb). This criterion was also exceeded in the one sample from the control station in Lake Erie. In the lower Niagara, a greater percentage of samples exceeded the criteria for arsenic, chromium and mercury. The high concentrations of PCBs, mirex, DDT, and other organics in the sediments and suspended sediments at Environment Ontario stations NiL-7 and NiL-9 downstream of Queenston, Ontario, suggest that this is a depositional area for contaminants.

Further comparison of concentrations at various river locations is awaiting the completion of sediment particle size and organic carbon analysis.

(5) Biota

(a) Macroinvertebrates, Macrophytes, Net Plankton and Clams

Laboratory analyses of macroinvertebrates (Amphipods, snails, worms, leeches, clams), macrophytes (rooted aquatic plants as well as *Cladophora*) and net plankton (phytoplankton and zooplankton) are presently available for only some of the sites sampled in 1979 by Environment Ontario, and these are all from the lower Niagara River. Table D compares the mean concentrations of heavy metals, arsenic, PCBs and pesticides in these three components of the aquatic environment. Generally, there appears to be little difference in the concentrations of metals and arsenic between macrophytes and macroinvertebrates (and between stations) with the exception of higher concentrations of chromium and copper in the macroinvertebrates from station NiL-1, near Niagara-on-the-Lake. However, this is not the case for PCBs and pesticides. The number of pesticides detected in macroinvertebrates were greater than in macrophytes. When comparisons were made between these two groups and between stations, the mean concentrations of PCBs and pesticides were often higher in macroinvertebrates by a factor of up to 10 (eg. PCBs, station NiL-2; total DDT, Station NiL-7). The single sample of net plankton (net mesh size: 120 μm) for which only PCBs and pesticides data are available (station NiL-2) contained detectable quantities of only p,p-DDE and PCB. The PCB concentration in net plankton (870 ppb) was much higher than the means of levels found in macrophytes (7 to 31 ppb) or macroinvertebrates (68 to 209 ppb). The significance of this information is unclear at present.

Results of analyses on clean (ie. unpolluted) freshwater clams placed in cages in the lower Niagara River for two months in 1978 by the Canadian Wildlife Service indicated detectable accumulations of PCBs, (30 ppb), DDE (10 ppb), HCB (4 ppb), pentachlorobenzene (1 ppb) and tetrachlorobenzene (4 ppb).

(b) Fish

Young-of-the-year spottail shiners have been collected from stations on the Niagara River (NiL-7, downstream of Queenston and NiL-1 at Niagara-on-the-Lake) and the control site at Thunder Bay, Lake Erie (station TB-1) during various years between 1975 and 1979. Briefly, results indicated that:

(i) Of the 13 contaminants analyzed for in 1979 (organochlorines and mercury), only PCB residues in fish from the two Niagara River sites exceeded the Agreement objective (100 ng/g wet weight, whole fish) for the protection of aquatic life and fish-eating birds.

(ii) Significant declines have been observed in PCBs, total DDT and mercury levels in fish from the Niagara-on-the-Lake site since monitoring began in 1975. PCB residues have decreased by 78%, total DDT by 89% and mercury by 33%.

(iii) Comparison of 1979 Niagara River data with the Lake Erie control at Thunder Bay indicates the presence of PCB, DDT, mirex, HCB and mercury inputs to the Niagara River.

Between 1976 and 1979, analyses of adult sport fish indicated that the following species were fit only for occasional consumption due to PCB and mirex levels which exceeded the National Health and Welfare guidelines of 2 ppm and 0.1 ppm (edible portion), respectively:

(i) coho salmon greater than 22 inches in the lower Niagara River

(ii) rainbow smelt greater than 6 inches and lake trout greater than 10 inches from Niagara-on-the-Lake to St. Catharines.

(6) Drinking Water Quality

Drinking water supplies on the Niagara River have been monitored for conventional indicators of public health suitability and potability since the early 1900's. More recently, the concern about persistent toxic substances reaching the river from industrial sources has led to the incorporation of additional parameters including PCBs, mirex, pesticides and other hydrocarbons into the regular monitoring programs. Monthly sampling has been carried out on raw water at the Niagara-on-the-Lake and Niagara Falls, Ontario water treatment plants and at a location in the Niagara River adjacent to the Town of Fort Erie. Table E summarizes the results of the analyses of raw water at the three locations. The data indicate that:

(i) At all three locations, all samples fell within the concentration criteria for acceptable (treated) drinking water as contained in the publications "Drinking Water Objectives" (Environment Ontario, 1978) and "Guidelines for Canadian Drinking Water Quality, 1978" (National Health and Welfare, 1978).

(ii) A number of organic compounds for which no drinking water objectives have as yet been established were present at parts-per-trillion levels (near the limit of detection) in some samples from all three locations. The significance of levels of these compounds is being investigated.

A comparison of the 1978-79 treated water results with an earlier province-wide study of the trihalomethane group of compounds shows no apparent change in contaminant levels in the Niagara-on-the-Lake water supply. The 1977 survey which included 40 surface water supplies in the province indicated that the Niagara-on-the-Lake supply had levels close to the median value from all plants (Organics in Drinking Water, Environment Ontario, 1977).

B. INPUTS (Industrial and Municipal)

A considerable volume of data exists on average daily industrial and municipal inputs, or loadings, to the Niagara River watershed (Inventory of Major Municipal and Industrial Point Source Dischargers in the Great Lakes Basin - July 1979, IJC). As would be expected from its greater industrial base and population, inputs from New York State exceed those from Ontario for most of the parameters listed in Table F. However, most of these data deal with conventional waste loading parameters (e.g., BOD, suspended solids, phosphorus). Monitoring of industrial and municipal effluents for the organics and inorganics discussed elsewhere in this report has been implemented only recently. Data are insufficient at present to allow for adequate quantification or comparison of loadings of these substances.

Some of these substances have been detected in tributary streams receiving industrial and municipal effluents. Analyses of 1979 water and suspended sediment samples collected by Environment Ontario indicate that the Buffalo River and Tonawanda Channel are sources of such contaminants as PCBs, dieldrin, DDT, arsenic, cadmium, chromium, copper, lead, nickel and zinc. In addition, the Buffalo River appears to be a source of α- and γ-chlordane, lindane, α-BHC, and the Tonawanda Channel a source of HCB, endrin, heptachlor epoxide and mercury. Results of other surveys indicate that Frenchman's Creek is a possible source of phosphorus, organic carbon, arsenic, chromium, nickel and zinc and the Welland River/Chippawa Hydro Electric Power Canal a possible source of phosphorus, ammonia, arsenic, iron, cadmium, chromium, copper, lead, nickel, zinc, PCBs and HCB to the Niagara River.

C. IMPACT ON LAKE ONTARIO

The Niagara River is the single largest tributary source to Lake Ontario. There are a large number of synthetic compounds detected in the river ecosystem (sediment, water, suspended sediments, biota) some of which have yet to be quantified or even specifically identified. Some of these could have adverse effects on human health and the environment. These substances eventually reach Lake Ontario. In some cases, conditions in the lake can be directly related to the Niagara River as the predominant input source (eg. mercury and mirex in sediments, mirex in herring gulls and fish).

Sources of information for the following assessment have included the International Reference Group on Great Lakes Pollution from Land Use (PLUARG) for data on sediments, the Department of Fisheries and Oceans (Canada) for data on fish and the Canadu ''ildlife Service for data on herring gull eggs.

(1) Sediments

Unlike rivers, lakes accumulate sediments progressively and sequentially. These sediments constitute a potential source of stored energy, nutrients and substances such as metals and organics. They also constitute a chronological record of processes in the lake and conditions in the watershed. Information on the vertical distribution of substances in sediment cores and horizontal variations in concentrations in the lake bottom is extremely useful in determining trends in the rates of input of substances and in tracing their movement from sources to sinks. Figures 4, 5 and 6 indicate the distribution of mercury, PCBs and mirex, respectively, in the Great Lakes and Lake Ontario sediments (from PLUARG, 1978).

(2) Fish

Table G compares the mean, whole body levels of trace contaminants in rainbow smelt from Lake Ontario. Fish collected in the Vineland - Niagara River area, as compared to the Eastern Basin area, contained

higher mean concentrations of PCBs (2.12 vs 0.98 μg/g wet weight), total DDT and metabolites (0.54 vs 0.25 μg/g), mirex (0.08 vs 0.03 μg/g), and mercury (0.09 vs. 0.06 μg/g). Fish from both areas contained mean PCB and mirex concentrations in excess of the 1978 Agreement specific objectives (0.1 and 0.01 μg/g wet weight, whole fish, respectively) for the protection of birds and animals which consume fish.

Table H indicates that mirex concentrations in coho salmon collected near Vineland in Lake Ontario were twice the Agreement specific objective (0.01 μg/g wet weight). Octachlorostyrene, polybrominated biphenyls (PBBs) and all mirex degradation products except photomirex, although not routinely analyzed for, were below their respective detection limits (values prefixed by <) in these fish samples.

(3) Herring Gulls

The extremely high bioconcentration of persistent contaminants from fish into herring gull tissues has facilitated the identification of specific compounds associated with industrial processes known to occur in the Niagara River and an examination of their spatial distribution and temporal trends. For example, at present (1979) six different mirex photo-degradation products, in addition to mirex, are accumulating in Lake Ontario herring gull eggs. These include mirex (II), 10-monohydromirex, 9-monohydromirex, 8-monohydromirex, 2,8-dihydromirex, and dihydromirex (II). Lake-wide mean concentrations have been included in Table H for comparison with those found in Vineland coho salmon. The small standard deviations, despite the fact that the means represent widely-separated colonies, may indicate the lake-wide influence of the Oswego and Niagara Rivers, the two major sources of mirex. Where comparisons are possible, the data indicate concentrations of mirex products in the eggs which are up to 100 times or more of those found in the fish (eg. 2.58 vs 0.02 μg mirex/g).

Temporal trends for mirex in Lake Ontario herring gull eggs indicate that the concentration has been declining steadily since 1974 with an approximate half-life of 1.9 to 2.2 years. This rapid removal of mirex may largely reflect the rapid sedimentation rate in Lake Ontario and the termination or decline in source outputs in the Oswego and the Niagara Rivers.

Spatially, 1979 levels of PCBs, mirex, HCB and DDE in herring gull eggs increased 1.5-to 2-fold between Port Colborne (Lake Erie) and the Niagara River and 2-to 3-fold between Port Colborne and Toronto. Lake Erie herring gull eggs are the least contaminated of those in the Great Lakes system, whereas those in Lake Ontario exhibit the highest organochlorine contaminants levels.

Recently, considerable attention has been focussed generally on tetrachlorodibenzodioxins (TCDDs), and, specifically, the 2,3,7,8-TCDD isomer. The Niagara River area herring gull eggs did not contain detectable levels of any TCDD isomers in 1979 (detection limit: $\leq$ 2 ng/kg = ppt).

The same gull egg tissues are presently being analyzed for other polychlorinated dibenzodioxins, polychlorinated dibenzofurans, lead and mercury.

II. CONCLUSIONS

(1) Yearly average water quality conditions in the Niagara River over the period 1975-1979 met the 1978 Canada/U.S. Great Lakes Water Quality Agreement water quality objectives. Concentrations exceeding the objectives for some metals and organic compounds occurred in less than 10% of the samples analyzed.

(2) All water samples taken along the Ontario shoreline of the river met the Canadian criteria for drinking water. (Health implications of a number of organics for which no objectives now exist are being investigated e.g., halogenated aliphatics other than trihalomethanes, and aromatic hydrocarbons.)

(3) Concentrations of PCBs, total DDT and mercury have declined significantly since 1975 in spottail shiners (an indicator forage fish species) caught at Niagara-on-the-Lake. Specific objectives for the protection of fish and other biota have not been established for a number of organic compounds present in the Niagara River ecosystem. Further investigation is proceeding under the Canada/U.S. Agreement.

(4) The Niagara River is a continuing source of numerous metals and organic compounds, including mercury, PCBs, mirex and DDT, to Lake Ontario because there are continuing inputs of these substances to the Niagara River itself. The range in observed concentrations of metals and organic compounds at the mouth of the river indicates that these inputs to the River are both variable and intermittent.

(5) While surveillance efforts of river water quality have been increased, industrial and municipal effluent monitoring with respect to synthetic organics and other potentially toxic substances should be strengthened.

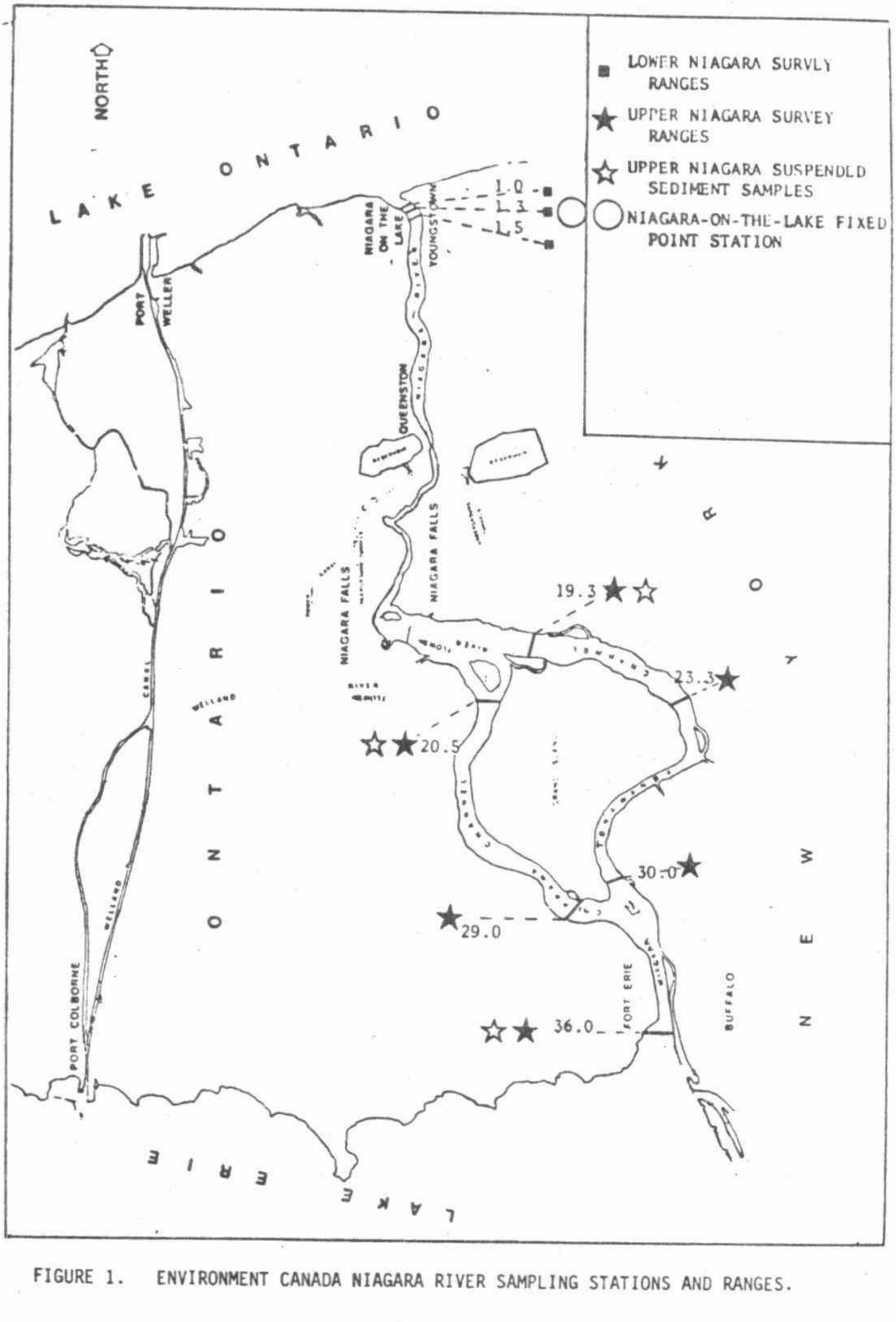

FIGURE 1. ENVIRONMENT CANADA NIAGARA RIVER SAMPLING STATIONS AND RANGES.

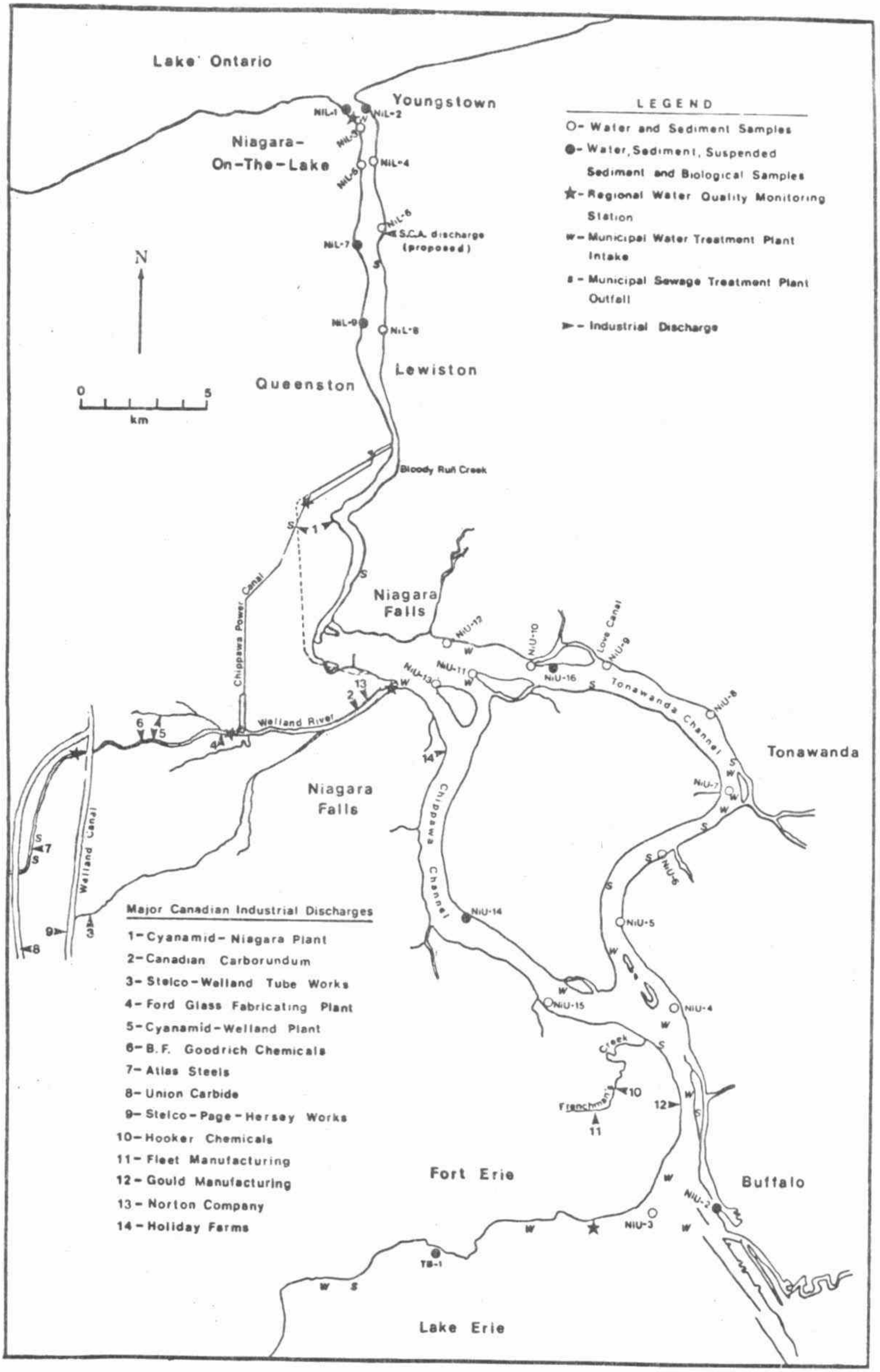

FIGURE 2. ENVIRONMENT ONTARIO 1979 NIAGARA RIVER SAMPLING STATIONS.

TABLE A: SUMMARY OF 1979 D.O.E. AND M.O.E. WATER QUALITY ANALYTICAL RESULTS FOR PCBs, PESTICIDES, ARSENIC AND HEAVY METALS (μg/l=ppb)

PARAMETER	1978 IJC Spec. Objective	1978 MOE Aquatic Life Objective	LOWER NIAGARA		UPPER NIAGARA/CANADIAN SIDE				UPPER NIAGARA/U.S. SIDE					
			Range 1.3	Station Nil-3	Range 20.5	Station NiU-13	Range 36.0	Station NiU-3	Range 19.3	Station NiU-10	Range 23.3	Station NiU-8	Range 30.0	Station NiU-5
PCB		.001**	-	<.020	<.020	<.020	.020*	<.020	.020*	.080*	<.020	.020*	<.020	<.020
Aldrin	.001	.001	-	<.001	-	<.001	-	<.001	-	<.001	-	<.001	-	<.001
Dieldrin			-	<.001	.001	.008*	.001	.003*	<.001	.020*	.001	<.001	<.001	.007*
α-BHC			-	<.001	.007	<.001	.005	.004	.005	<.001	.007	<.001	.006	<.001
β-BHC			-	<.001	-	<.001	-	<.001	-	<.001	-	<.001	-	<.001
Lindane (γ-BHC)	.010	.010	-	<.001	<.001	<.001	.001	<.001	.001	<.001	.001	<.001	.001	<.001
α-Chlordane	.060	.060	-	<.001	-	<.001	-	<.001	-	<.001	-	<.001	-	<.001
γ-Chlordane			-	<.001	-	<.001	-	<.001	-	<.001	-	<.001	-	<.001
o,p-DDT			-	<.005	-	<.005	-	<.005	-	<.005	-	<.005	-	<.005
p,p-DDT			-	<.005	-	<.005	-	.005	-	<.005	-	<.005	-	<.005
p,p-DDE			-	<.001	-	<.001	-	<.001	-	<.001	-	<.001	-	<.001
p,p-DDD (TDE)			-	<.005	-	<.005	-	<.005	-	<.005	-	<.005	-	<.005
ΣDDT + metabolites	.003	.003**	-	<.005	-	<.005	-	.005*	-	<.005	-	<.005	-	<.005
Endrin	.002	.002	-	<.001	-	<.001	-	<.001	-	<.001	-	.030*	-	<.001
Heptachlor	.001	.001	-	<.001	-	<.001	-	<.001	-	<.001	-	<.001	-	<.001
Heptachlor epoxide			-	<.001	-	.002*	-	<.001	-	.005*	-	.002*	-	.001
HCB			-	<.001	-	<.001	-	<.001	-	.010	-	.015	-	<.001
Mirex	<detection limit	.001**	-	<.005	-	<.005	-	<.005	-	<.005	-	<.005	-	<.005
Thiodan I		.003	-	<.001	-	<.001	-	<.001	-	<.001	-	<.001	-	<.001
Thiodan II			-	<.001	-	<.001	-	<.001	-	<.001	-	<.001	-	<.001
Phenols		1	-	-	<1	-	<1	-	<1	-	<1	-	<1	-
Cn		5	2	-	4	-	1	-	2	-	4	-	2	-
Al			96	-	-	-	-	-	-	-	-	-	-	-
As	50	100	-	<1	-	<1	-	-	-	1	-	<1	-	<1
Cd	0.2	0.2**	<1	10*	<1	<5	<1	-	<1	<5	<1	<5	<1	<5
Cr	50	100	2	<20	<1	<20	<1	-	1	<20	1	<20	1	30
Cu	5	5**	8*	<10	1	<10	3	-	2	<10	3	<10	3	<10
Fe	300	300	375*	-	130	-	119	-	220	-	213	-	139	-
Pb	25	25**	2	<30	1	<30	1	-	2	<30	1	<30	1	<30
Mn			11	-	4	-	5	-	8	-	7	-	5	-
Hg	0.2	0.2	<.05	.07	-	.09	-	-	-	.08	-	.11	-	.08
Ni	25	25	3	<20	2	<20	3	-	2	<20	3	<20	3	<20
Zn	30	30	5	<10	2	<10	5	-	9	20	11	<10	4	<10

A dash (-) indicates no data available.

NOTE: Objectives given where available.

* IJC and/or MOE objective for protection of aquatic life exceeded.

** NOTE: Detection Limit exceeds objective.

Range = DOE data
Station = MOE data

TABLE B: SUMMARY OF 1979 D.O.E. AND M.O.E. SUSPENDED SEDIMENT ANALYTICAL RESULTS FOR PCB, PESTICIDES (ng/g = ppb) AND METALS (μg/g = ppm) - MEANS AND STANDARD DEVIATIONS

PARAMETER	Lower Niagara		Upper Niagara		Lake Erie (Thunder Bay)
	DOE[(a)]	MOE[(b)]	DOE[(c)]	MOE[(d)]	MOE[(e)]
PCB	1080±253(28) 493±30(25)*	137±84(3)	260±35(3)	673±520(3)	450
Aldrin	N.D. (28)	N.D. (3)	N.D.	N.D.	N.D.
Dieldrin	9±4(28)	8±7(3)	23 (3)	11±6(3)	1
α-BHC	74±162(28) 16±10(26) *	5±7(3)	-	1±2(3)	N.D.
β-BHC	-	N.D. (3)	-	N.D. (3)	N.D.
Lindane (γ-BHC)	19±11(28)	3±4(3)	N.D. (3)	1±2(3)	N.D.
α-Chlordane	22±12(28)	4±7(3)	8 (3)	2±3(3)	N.D.
γ-Chlordane		15±26(3)		2±3(3)	N.D.
o,p-DDT	15 (27)	N.D. (3)	11 (3)	8±3(3)	N.D.
p,p-DDT	12±6(28)	N.D. (3)	8±2(3)	9±8(3)	N.D.
p,p-DDE	25±13(28)	8±2(3)	15 (3)	14±12(3)	30
p,p-TDE(DDD)	9±5(27)	3±6(3)	N.D. (3)	9±4(3)	N.D.
Σ-DDT + metabolites	34±16(28)	11±6(3)	22±12(3)	39±6(3)	30
Endrin	N.D. (28)	0.3±0.6(3)	N.D. (3)	N.D. (3)	N.D.
Heptachlor	N.D. (28)	N.D. (3)	N.D. (3)	N.D. (3)	N.D.
Heptachlor epoxide	N.D. (28)	5±5(3)	N.D. (3)	0.7±1(3)	N.D.
HCB	106±130(28)	38±51(3)	-	13±15(3)	N.D.
Mirex	30±61(28) 13±8(26)*	41±60(4)	N.D (3)	9±5(3)	20
Thiodan I	12±4(27)	5±5(3)	N.D. (3)	N.D. (3)	N.D.
Thiodan II	N.D. (28)	13±18(3)	N.D. (3)	N.D. (3)	N.D.
Methoxychlor	19±16(28)	-	N.D. (3)	-	-
As	-	19±3(4)	-	12±5(3)	-
Cd	-	4±1(4)	-	5±3(3)	7
Cr	-	76±10(4)	-	113±42(3)	<53
Cu	-	102±34(4)	-	223±58(3)	170
Pb	-	133±30(4)	-	200±167(3)	79
Hg	-	0.7 (2)	-	0.8 (2)	0.1
Ni	-	50±4(4)	-	78±15(3)	92
Zn	-	350±42(4)	-	573±355(3)	160

(a) = mean of Niagara-on-the-Lake samples
(b) = mean of stations NiL-2, -7, -9, -1
(c) = mean of ranges 19.3, 20.5, 36.0
N.D. = below detection limit
- = not analyzed for or data not yet available

(d) = mean of stations NiU-2, -14, -16
(e) = station TB-1 (one sample)
* = with and without high values
figures in brackets ( ) indicate number of samples analyzed.

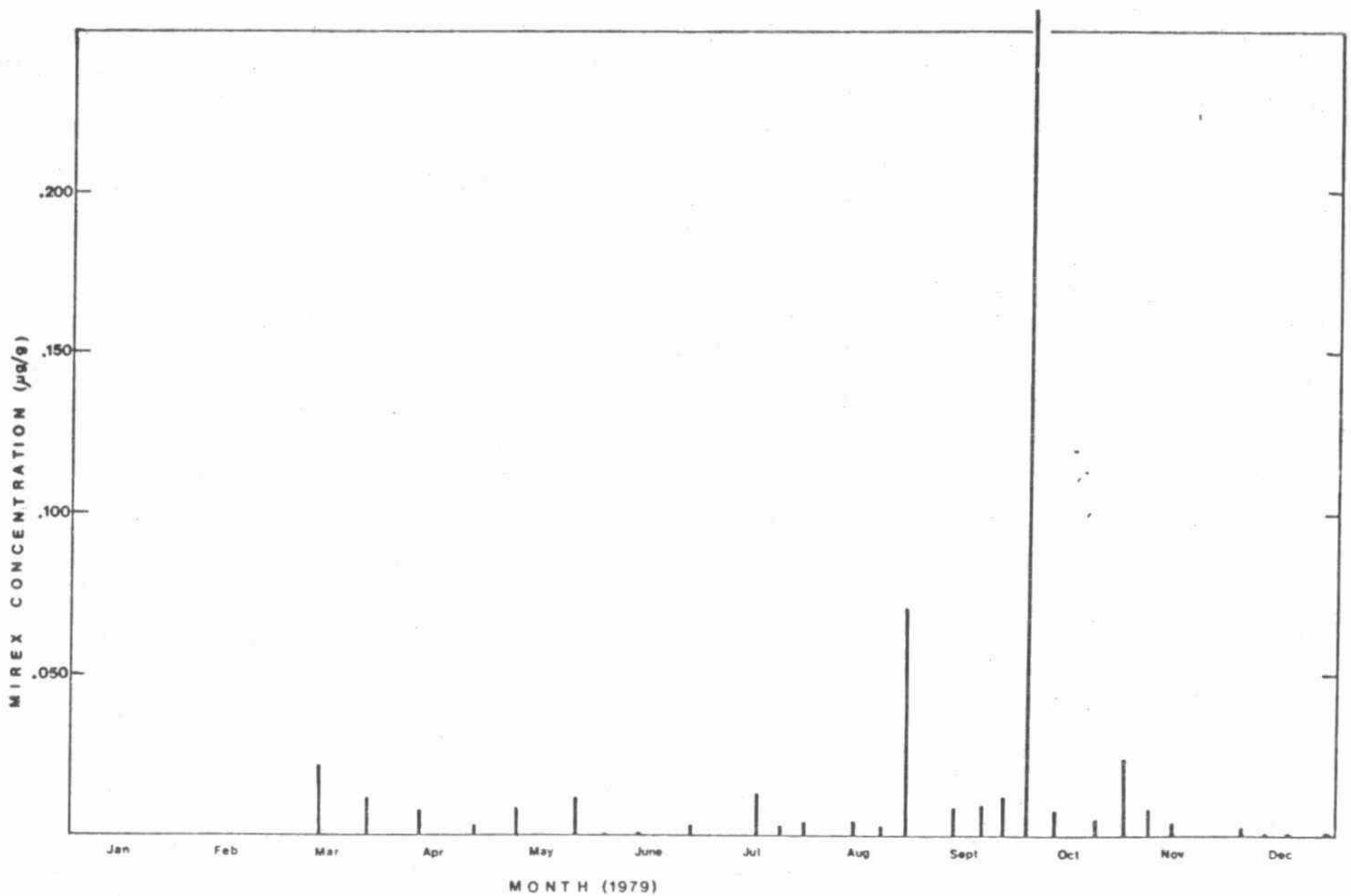

FIGURE 3. MIREX CONC'N. IN NIAGARA RIVER SUSPENDED SEDIMENT.

TABLE C: PERCENTAGE OF 1979 MOE SURVEY SEDIMENT SAMPLES WHICH EXCEEDED MOE DREDGE SPOIL DISPOSAL CRITERIA

PARAMETER	PERCENTAGE EXCEEDING CRITERIA		
	MOE DREDGE SPOIL DISPOSAL CRITERION	LOWER NIAGARA	UPPER NIAGARA
PCB	50 ppb	100 (8)	83 (12)
As	8 ppm	11 (9)	7 (14)
Cr	25 ppm	44 (9)	21 (14)
Cu	25 ppm	22 (9)	21 (14)
Pb	50 ppm	11 (9)	21 (14)
Hg	0.3 ppm	56 (9)	21 (14)
Ni	25 ppm	0 (9)	14 (14)
Zn	100 ppm	44 (9)	50 (14)

Figures in brackets ( ) are numbers of samples used to calculate percentage.

TABLE D: MEANS AND STANDARD DEVIATIONS (ng/g = ppb) OF PCBs, PESTICIDES, ARSENIC AND VARIOUS HEAVY METAL CONCENTRATIONS IN BIOTA COLLECTED FROM THE LOWER NIAGARA RIVER IN 1979 BY MOE.

PARAMETER	Macrophytes				Macroinvertebrates				Net Plankton
Station:	Nil-1	Nil-2	Nil-7	Nil-9	Nil-1*	Nil-2	Nil-7	Nil-9	Nil-2*
PCB	18±16	7±12	31±12	-	-	158±68	209±228	68±63	870
Aldrin	N.D.	N.D.	N.D.	-	-	N.D.	N.D.	N.D.	N.D.
Dieldrin	N.D.	1.4±2.4	N.D.	-	-	0.4±0.9	5.3±11	N.D.	N.D.
α-BHC	N.D.	N.D.	N.D.	-	-	11±8	4.8±6.2	0.8±1.5	N.D.
β-BHC	N.D.	N.D.	0.7±1.2	-	-	N.D.	3.3±6.5	N.D.	N.D.
Lindane (γ-BHC)	N.D.	0.6±1.0	0.8±1.2	-	-	3.7±3.9	9.3±11	N.D.	N.D.
α-Chlordane	2.0±0.0	N.D.	0.3±0.6	-	-	N.D.	14±14	5.0±3.9	N.D.
γ-Chlordane	1.0±0.0	N.D.	N.D.	-	-	N.D.	12±17	6.3±5.1	N.D.
o,p-DDT	N.D.	N.D.	N.D.	-	-	N.D.	3.0±6.0	N.D.	N.D.
p,p-DDT	N.D.	N.D.	N.D.	-	-	N.D.	5.3±11	N.D.	N.D.
p,p-DDE	2.0±0.0	N.D.	1.5±0.1	-	-	6.6±4.0	3.8±2.8	2.0±1.8	15
p,p-DDD	N.D.	N.D.	N.D.	-	-	1.8±4.0	10±5.6	5.8±5.4	N.D.
Σ-DDT + metabolites	2.0±0.0	N.D.	1.5±0.1	-	-	8.4±4.0	22±11	7.8±5.4	15
Endrin	N.D.	N.D.	N.D.	-	-	0.8±1.8	1.3±2.5	N.D.	N.D.
Heptachlor	N.D.	N.D.	N.D.	-	-	N.D.	N.D.	N.D.	N.D.
Heptachlor epoxide	N.D.	3.2±0.7	2.1±2.0	-	-	9.8±15	1.8±3.5	1.0±0.7	N.D.
HCB	N.D.	N.D.	N.D.	-	-	0.4±0.9	0.9±1.1	N.D.	N.D.
Mirex	N.D.	N.D.	N.D.	-	-	N.D.	N.D.	N.D.	N.D.
Thiodan I	N.D.	2.5±3.4	N.D.	-	-	3.4±4.7	N.D.	0.3±0.7	N.D.
Thiodan II	N.D.	2.2±3.8	0.5±1.0	-	-	11±18	1.5±3.0	N.D.	N.D.
As	2.3±0.8	4.5±2.7	4.4±5.7	3.3±2.5	2.6	4.2±4.6	2.9±1.0	2.8±2.3	-
Cd	1.8±1.0	1.6±0.2	0.9±0.3	1.4±0.8	<2.6	2.3±1.8	0.9±0.1	1.5±0.5	-
Cr	14±3.8	7.7±4.8	5.5±4.0	11±6.7	33	102±163	3.8±0.0	13±11	-
Cu	31±11	116±101	58±49	37±13	93	66±42	113±81	44±35	-
Pb	12±1.5	29±12	27±29	13±7.7	18	21±23	4.9±0.1	9.0±4.9	-
Hg	0.12±0.04	0.12±0.09	0.12±0.12	0.03±0.02	0.19	0.02±0.03	0.07±0.02	0.06±0.03	-
Ni	12±1.7	28±6.5	15±12	18±7.6	<10	9.5±6.7	8.7±4.7	7.9±5.0	-
Zn	94±37	115±44	75±64	88±34	90	268±206	94±52	112±91	-

* only one sample or species analyzed

N.D. = below detection limit

\- = not yet analyzed

TABLE E: COMPARISON OF RANGE OF CONCENTRATIONS OF CONTAMINANTS DETECTED IN RAW WATER AT TREATMENT PLANTS

Concentration Range* in Water Treatment Plant Intake[x] and Upper Niagara River Waters[+] (μg/l = ppb)

Parameter	(1) 1978 H&WC Drinking Water Max. Allow. Conc.	Niagara-on-the-Lake[x]		Niagara Falls[x]		Fort Erie[+]	
		1974 to 1978	1979	1974 to 1978	1979	1974 to 1979	1979
PCBs	-	N.D.	N.D.-0.020	N.D.	N.D.	N.D.	N.D.
Aldrin	} 0.7	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Dieldrin		N.D.	N.D.-0.002	N.D.	N.D.-0.002	N.D.	N.D.-0.004
α-BHC	-	N.D.	N.D.-0.003	N.D.	N.D.-0.005	N.D.	N.D.-0.004
β-BHC	-	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Lindane (γ-BHC)	4	N.D.-0.030***	N.D.-0.002	N.D.	N.D.-0.003	N.D.	N.D.-0.003
α-Chlordane	} 7	N.D.	N.D.	N.D.	N.D.	} N.D.	} N.D. - 0.001
γ-Chlordane		N.D.	N.D.	N.D.	N.D.		
Σ DDT + metabolites (2)	30	N.D.	N.D.	N.D.	N.D.-0.005	N.D.	N.D.-0.005
Endrin	0.2	N.D.	N.D.-0.003	N.D.	N.D.	N.D.	N.D.
Heptachlor	} 3	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Heptachlor epoxide		N.D.	N.D.-0.010	N.D.	N.D.	N.D.	N.D.
HCB	-	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Mirex**	-	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Thiodan I (α-Endosulfan)	-	N.D.	N.D.-0.003	N.D.	N.D.	N.D.	N.D.
Thiodan II (β-Endosulfan)	-	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Total Pesticides	100	-	-	-	-	-	-

N.D. = below detection limit

- = not available

* one sample each from 1974, 1975 and 1978; seven samples from 1979

** analysis for Mirex begun in 1976

*** Lindane only detected in 1974

NOTE: (1) Health & Welfare Canada maximum acceptable concentrations in drinking water - objective concentration for each pesticide is 0.0005 ppb.

(2) (pp-DDT)

TABLE E cont'd

Concentration Range* in Water Treatment Plant Intake[x] and Upper Niagara River Waters[+] (μg/l = ppb)

Parameter	(1) 1978 H&WC Drinking Water Max. Allow. Conc.	Niagara-on-the-Lake[x] 1978	Niagara-on-the-Lake[x] 1979	Niagara Falls[x] 1978	Niagara Falls[x] 1979	Fort Erie[+] 1978	Fort Erie[+] 1979
Alkanes:							
Hexane	-	N.D.	Tr. to +	N.D.	Tr. to +	N.D.	N.D. to Tr.
Alkenes:							
Methyl pentene	-	N.D.	N.D. to +	N.D.	N.D.	N.D.	N.D.
Aliphatics:	-	N.D.	N.D. to +	N.D.	Tr. to +	N.D.	N.D. to Tr.
Halogenated Aliphatics:							
Carbon tetrachloride	-	N.D.	N.D. to Tr.	N.D.	N.D.	N.D.	N.D. to 0.012
Bromoform		N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Chloroform	350**	N.D. to Tr.	N.D. to 0.267	N.D. to Tr.	N.D. to 0.205	N.D. to Tr.	N.D. to 0.118
Chlorodibromomethane		N.D.	N.D. to +	N.D.	N.D.	N.D.	N.D.
Dichlorobromomethane		N.D.	N.D. to 0.020	N.D.	N.D.	N.D.	N.D.
Dichloroethane	-	N.D.	N.D. to Tr.	N.D.	N.D.	N.D.	N.D.
Dichloropropane	-	N.D.	N.D. to Tr.	N.D.	N.D.	N.D.	N.D.
Methylene chloride	-	N.D.	N.D. to 9.00	N.D.	N.D. to 4.00	N.D.	N.D. to 3.000
Tetrachloroethylene	-	N.D.	N.D. to 0.069	N.D.	N.D. to 0.006	N.D.	N.D. to 0.100
Trichloroethane	-	N.D.	N.D. to +	N.D.	N.D.	N.D.	N.D. to +
Trichloroethylene	-	N.D. to Tr.	N.D. to 0.184	N.D.	N.D. to 0.025	N.D. to Tr.	N.D. to 0.015
Dichloropropylene	-	N.D.	N.D.	N.D. to Tr.	N.D.	N.D.	N.D.
Aromatics:							
Benzene	-	N.D. to 0.190	N.D. to 0.263	N.D. to 0.340	N.D. to 0.059	N.D. to 0.170	N.D. to 0.052
Tri-methyl benzene	-	N.D.	N.D.	N.D. to Tr.	N.D.	N.D.	N.D.
Ethyl benzene	-	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Di-ethyl benzene	-	N.D. to Tr.	N.D. to 0.059	N.D.	N.D.	N.D.	N.D.
Cumene	-	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Toluene	-	N.D. to 0.200	N.D. to 0.049	N.D. to 0.176	N.D. to 0.063	N.D. to 0.270	N.D. to 0.065
Ethyl toluene	-	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Xylene(s)	-	N.D. to 0.250	N.D. to 0.030	N.D. to 0.010	N.D.	N.D. to 0.650	N.D. to 0.025
Halogenated Aromatics:							
Chlorobenzene	-	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Chlorotoluene	-	N.D. to Tr.	N.D.	N.D.	N.D.	N.D.	N.D.
Alcohols and Ethers:							
Isobutanol	-	N.D.	+	N.D.	N.D.	N.D.	N.D.
Ether	-	N.D.	Tr.	N.D.	N.D.	N.D.	N.D.
Di-ethyl ether	-	N.D.	+	N.D.	+	N.D.	N.D.

* five samples from 1978; six samples from 1979

N.D. = below detection limit

Tr. = Trace

\+ = present but not quantitated

\- = not available

** objective concentration for Trihalomethanes is: 0.5 ppb

TABLE E cont'd

Concentration Range* in Water Treatment Plant Intake[x] and Upper Niagara River Waters[+] (p Ci/l)

Radionuclide	1978 MOE Drinking Water Criterion	Niagara-on-the-Lake[x]		Niagara Falls[x]		Fort Erie[+]	
		1978	1979	1978	1979	1978	1979
Gross α	-	<1	-	<1	-	-	-
Gross β	1,000	2	-	4	-	-	-
Cesium 134	-	<30	<30	<30	<30	-	<30
Cesium 137	-	<30	<30	<30	<30	-	<30
Cobalt 60	-	<30	<30	<30	<30	-	<30
Radium 226	3	<1	-	<1	-	-	-
Strontium 89	-	<0.1	<0.1	<0.1	0.3	-	<0.1
Strontium 90	10	0.9	0.7	<0.1	0.6	-	0.7
Tritium	-	<240	-	<240	-	-	-

* one sample only from each year

\- = not available

values prefixed by "<" are detection limits (Ontario Ministry of Labour)

Table F. Average Daily Loading (in kg) and Flow (in 10^3 m^3) OF MUNICIPAL AND INDUSTRIAL DISCHARGERS TO THE NIAGARA RIVER

	Daily Flow	BOD_5	COD	S.S.	D.S.	Tot. P	Tot. N	NH_3	NO_3^-	TOC	$SO_4^=$	H_2S
Municipal Direct	11.30	381.9		484.0		20.2	-					-
Industrial Direct	7.96	62.6		48.5		0.8	-					-
Municipal Indirect	75.10	2129.2		1640.2		58.0	-					-
Industrial Indirect	141.48	582.4		4653.9		71.4	16311.2					2.0
Total, Ontario	235.8	3156.1	N.A.	6826.6	N.A.	150.4	16311.2	N.A.	N.A.	N.A.	N.A.	2.0
Municipal Direct	1074.37	95096.2	-	70909.2	-	2528.3	-	-	-	-	-	-
Industrial Direct	421.74	729.8	3452.6	5294.6	39196.2	0.9	109.0[d]	233.1	24.0	265.5	39277.4	450.3
Municipal Indirect	-	-	-	-	-	-	-	-	-	-	-	-
Industrial Indirect	2.79	4.6	-	113.7	-	-	-	-	-	-	-	-
Total, New York	1498.9	95830.6	3452.6	76203.8	39196.2	2529.2	109.0	233.1	24.0	265.5	39277.4	450.3
Grand Total	1734.7	98986.7	3452.6	83030.4	39196.2	2679.6	16420.2	233.1	24.0	265.5	39277.4	452.3

(a) Cr^{6+}
(b) Free CN
(c) Soluble Fe
(d) as TKN

*Summarized from: Inventory of Major Municipal and Industrial Point Source Discharges in the Great Lakes Basin - July 1979, IJC
- based on annual average rates for the calendar year 1978 in Ontario and on an average of reported values for the last 6 months of 1977 and the first 6 months of 1978 in New York

Table F. Average Daily Loading (in kg) and Flow (in 10^3 m^3) (continued) OF MUNICIPAL AND INDUSTRIAL DISCHARGERS TO THE NIAGARA RIVER

	Al	Ba	B	Ca	Cd	Cl	Cr	Cu	F	Fe	Pb	Mn
Municipal Direct							-			-	-	
Industrial Direct							-			-	0.15	
Municipal Indirect							-			-	-	
Industrial Indirect							27.9			619.2	-	
Total, Ontario	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	27.9	N.A.	N.A.	619.2	0.15	N.A.
Municipal Direct	-	-	-	-	-	-	-	-	-	-	-	-
Industrial Direct	-	18.4	149.3	292898.5	0.08	1000.6	1.78	0.36	105.0	244.1 55.8(c)	0.23	0.70
Municipal Indirect	-	-	-	-	-	-	-	-	-	-	-	-
Industrial Indirect	0.45	-	-	-	-		0.20 0.27(a)	0.16	-	-	-	-
Total, New York	0.45	18.4	149.3	292898.5	0.08	1000.6	2.25	0.52	105.0	299.9	0.23	0.70
Grand Total	0.45	18.4	149.3	292898.5	0.08	1000.6	30.2	0.52	105.0	919.1	0.38	0.70

Table F. Average Daily Loading (in kg) and Flow (in 10^3 m^3) (continued)
OF MUNICIPAL AND INDUSTRIAL DISCHARGERS TO THE NIAGARA RIVER

	Mg	Hg	Zn	CN	Phenols	Toluene	Sol. Ext.	O & G	VCM	Mirex
Municipal Direct					-	-	-	-	-	
Industrial Direct					-	-	1.6	-	-	
Municipal Indirect					-	-	-	-	-	
Industrial Indirect					0.26	-	108.9	-	1.3	
Total, Ontario	N.A.	N.A.	N.A.	N.A.	0.26	-	110.2	-	1.3	N.A.
Municipal Direct	-	-	-	-	-	-	-	-	-	-
Industrial Direct	-	0.04	21.4	246.0 8.8[b]	24.7	0.34	-	457.8	-	0.004
Municipal Indirect	-	-	-	-	-	-	-	-	-	-
Industrial Indirect	67.4	-	0.17	-	-	-	-	30.9	-	-
Total, New York	67.4	0.04	21.6	254.8	24.7	0.34	-	488.7	-	0.004
Grand Total	67.4	0.04	21.6	254.8	25.0	0.34	110.2	488.7	1.3	0.004

Sol. Ext. (solvent extractables) ≃ O & G (oil and grease)
VCM = vinyl choride monomer
N.A. = not available

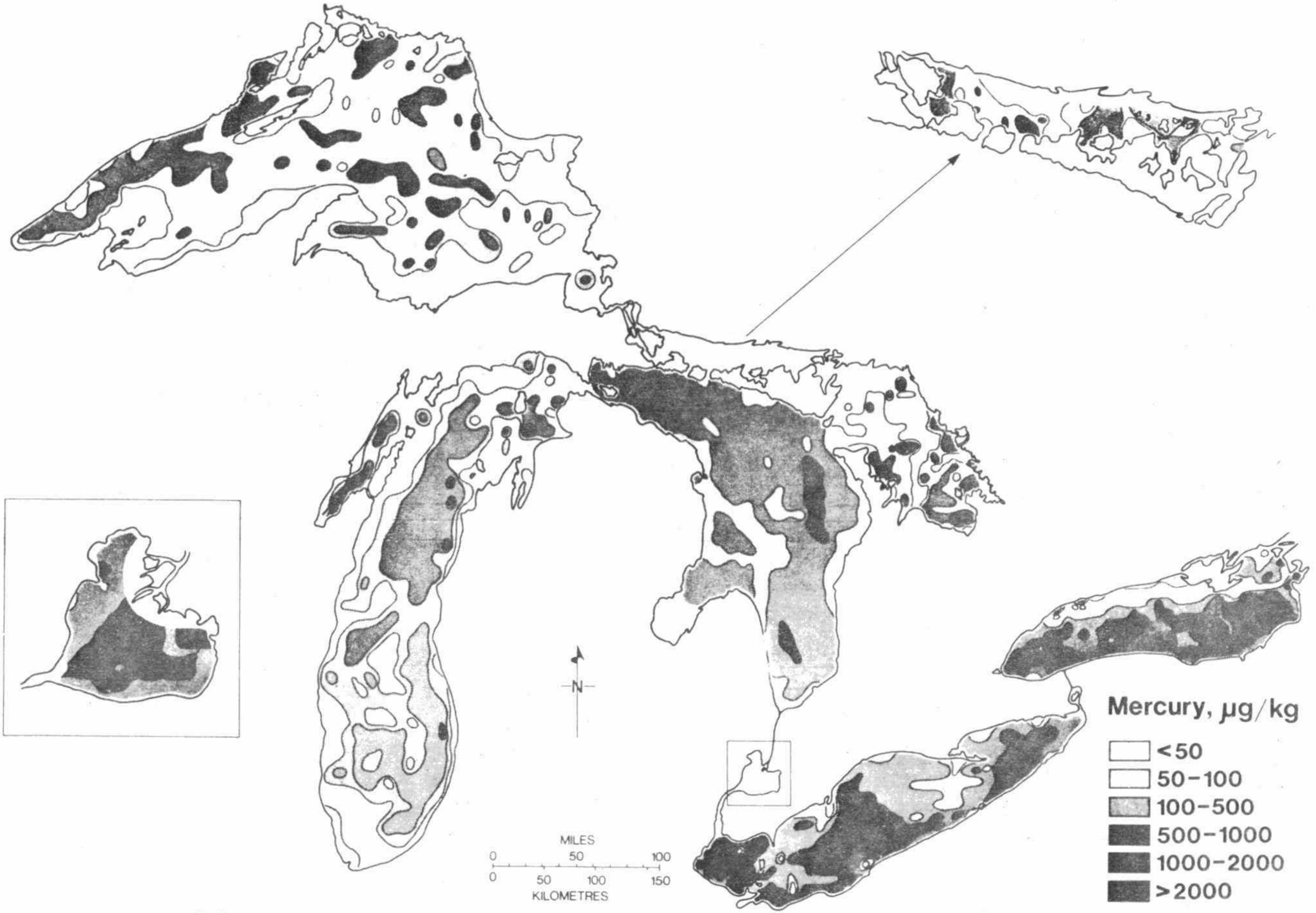

FIGURE 4: MERCURY CONCENTRATIONS IN SURFACE SEDIMENTS OF THE GREAT LAKES (ppb = µg/kg).

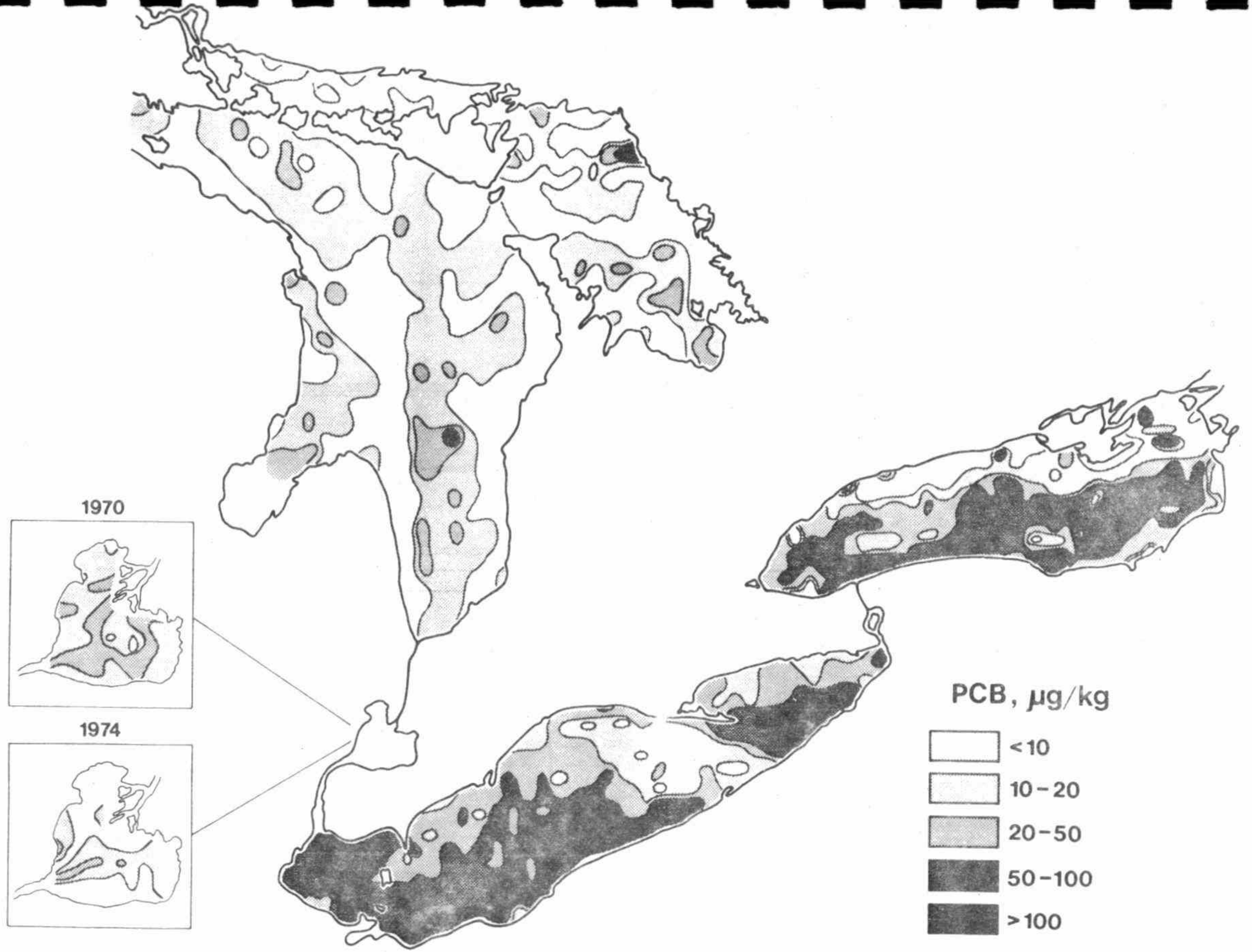

FIGURE 5: PCB CONCENTRATIONS IN SURFACE SEDIMENTS OF LAKES HURON, ERIE AND ONTARIO. (ppb = µg/kg)

Figure 6 Mirex in sediments of Lake Ontario. (1968)

TABLE G: COMPARISON OF TRACE CONTAMINANTS (mean and standard error in μg/g = ppm, wet wt., whole body) IN RAINBOW SMELT COLLECTED* IN TWO LAKE ONTARIO LOCATIONS IN 1978

Parameter	1978 Agreement Specific Objective	LAKE ONTARIO	
		Vineland-Niagara River	Eastern Basin
PCB	0.1	2.12±0.17	0.98±0.19
Dieldrin	0.01**	0.07±0.01	0.03±0.00
Chlordane	0.01**	0.01	0.02±0.00
o,p-DDT	0.01**	0.03±0.01	0.00
p,p-DDT	0.01**	0.03±0.00	0.01±0.00
p,p-DDE	0.01**	0.46±0.04	0.21±0.06
p,p-TDE (DDD)	0.01**	0.01±0.00	0.02±0.00
ΣDDT + metabolites	1.0	0.54±0.05	0.25±0.06
Heptachlor epoxide	0.01**	0.01	0.00
Mirex	0.01**	0.08±0.01	0.03±0.01
As	-	0.33±0.02	0.55±0.03
Cd	-	0.02±0.00	0.04±0.01
Cr	-	0.19±0.02	0.14±0.02
Cu	-	0.69±0.05	0.82±0.04
Pb	-	0.09±0.01	0.06±0.01
Hg	0.5	0.07±0.00	0.04±0.01
Ni	-	[illegible]±0.03	0.22±0.02
Se	-	0.36±0.01	0.37±0.02
Zn	-	23.80±0.96	24.00±0.47

* D.O.E., Water Quality Branch; 10 samples of 5 fish each analyzed

** specific objective not defined yet, but should be less than detection level by the best scientific methodology available (value beside asterisk)

\- = not available

TABLE H: COMPARISON OF TRACE CONTAMINANTS ($\mu g/g$ = ppm, wet wt.) IN COHO SALMON AND HERRING GULL EGGS FROM LAKE ONTARIO, 1979

Parameter	Coho Salmon - Vineland (L. Ontario)*	Herring Gull Eggs - Lake Ontario**
α-BHC	< 0.003	-
Lindane (γ-BHC)	< 0.003	-
HCB	0.008	-
Methoxychlor	N.D.	-
Mirex	0.02	2.58±0.40
Mirex (II)	-	0.039±0.011
Photomirex (8-monohydro-mirex)	0.003	0.95±0.14
9-monohydro-mirex	-	0.077±0.019
10-monohydro-mirex	< 0.001	0.119±0.025
dihydro-mirex (II)	-	0.016±0.005
2,8-dihydro-mirex	< 0.001	0.011±0.003
Octachlorostyrene	< 0.005	-
PBB (tetra-hexa)	< 0.02	-
TCDD	—	N.D.

* D.O.E., Water Quality Branch

** mean and standard deviation of colonies at Toronto, Presqu'ile, Kingston, Rochester, N.Y., Central Lake Ontario and the mouth of the St. Lawrence River - Canadian Wildlife Service

N.D. = below detection limit

\- = not available

The Canada-Ontario Agreement, (COA) on Great Lakes Water Quality was originally signed in 1971. The purpose of this Agreement is to ensure federal provindial co-operation in meeting the requirements of the Canada-U.S. Great Lakes Water Quality Agreement. Activities carried out under the auspices of COA are administered by the Canada-Ontario Review Board which is composed of senior officials of the Environment Canada, Fisheries and Oceans Canada, and the Ontario Ministries of Environment and Natural Resources.